

A STUDY OF THE ASTRAGALUS. By R. B. SEYMOUR
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Anthropological Institute.* (PLATES XX.-XXIII.)

PART III.

THE COLLUM TALII.

UNDER this name, as we have seen in the first part of this paper, is included the more or less roughened region of bone lying between the corpus posteriorly and the smooth, rounded, articular surface of the caput anteriorly. In section, this portion of bone is more or less rhomboidal in shape, and we can distinguish four surfaces—viz., a superior, a lateral or external, an inferior, and an internal or medial.

Length.—As a measurement of the length of the collum tali, I have taken the distance between the middle point of the anterior border of the trochlear surface behind and the facies articularis navicularis in front, measured in a direction parallel with the outer border of the neck. This measurement I have found to vary very considerably in different bones. The average length of the neck was 15 mm., but in certain specimens it differed from this to a very considerable extent; in No. 741 it was as great as 24 mm., while in several other cases it only measured 11 mm.

As an index of the length of the collum, I have taken

$$\frac{\text{length of neck} \times 100.}{\text{length of bone}}$$

(The total length of bone being taken as the distance between the floor of the sulcus musculi flexoris hallucis longi and the foremost point of the articular surface of the caput.) This, on the average, is found to be = 30, but the variations in the length of the neck, in specimens which possess the same maximum length measurement, give rise to very large differences in the values of this length-index, as will readily be seen from the following table:—

TABLE I.—*Showing Variations in the Length-Index of the Collum.*

No. of Bone.	Max. Length of Bone.	Length of Neck.	Index.
514	45 mm.	11 mm.	24
431	45 "	16 "	36
446	50 mm.	11 mm.	22
327	50 "	18 "	36
741	53 mm.	11 mm.	21
139	53 "	24 "	45

The length of the collum, in proportion to the maximum length of the bone, may differ in different races. Professor Havelock Charles notes that in the Punjabi the neck is much shortened in comparison with European bones (2). He does not, however, give any measurements, and I am inclined to think that this appearance is due mainly to the forward prolongation of the articular surfaces of the corpus.

The Superior Surface.—This surface is usually more or less rough. Both anteriorly and posteriorly it is sharply marked off by smooth articular surfaces, that in front being for the articulation of the scaphoid or navicular bone—the *facies articularis navicularis*—and that behind being the trochlear surface for the tibia. Externally the surface is marked off by a tubercular ridge from the lateral aspect, while internally it passes into the medial surface; occasionally all distinction into superior and medial regions is lost, and we get a continuous supero-internal surface, which is separated off from the external surface by the above-mentioned tubercular ridge, while inferiorly it ends abruptly at the border of the *facies articularis calcanea media*. This condition, however, seems to be of rare occurrence, and I have only found it in one specimen, No. 529.

Running parallel to the anterior border across the surface is a more or less well-marked ridge, which is continued internally on to the medial surface and may become continuous with the ridge which runs forwards on the internal aspect of the corpus

from the anterior margin of the tuberculum mediale (9). In such cases we get a continuous ridge extending across the medial and superior aspects of the bone; such a condition, however, occurs in only 3 per cent. of the bones (Nos. 41, 65, 71, 82, 154, 160, 189, 193, 247, 257, 307, 319, 424, 349, 418, 419, 447, 452, 529, 569, 607, 733, 801, 913, 964, 971, 972).

This ridge has been noted by Professor A. Thomson in the astragali of the Australian and the Andamanese, and in these races he finds that its upper surface is "usually smooth and fits into a hollow on the inferior margin of the tibia" (10).

In the fresh state, the ridge serves as an attachment for the ligamenta talo-navicularia superficialia et profundum. As Barclay-Smith has pointed out (1), the superficial ligament arises from the outer and upper aspect of the neck, while the deep runs from the upper and inner aspect, the two sets of fibres crossing one another.

The vestigial ligamentum talo-metatarsale also gains an attachment to this ridge; as Keith has shown (6), this fibrous band, which runs from the astragalus to metatarsal 3, and also to some extent to 2 and 4, is well marked in the anthropoid apes, and can also be seen in the human foetus, but becomes lost in adult life, owing to fusions taking place with other ligamentous bands.

The region of the neck lying in front of this ridge is usually smooth, so as to allow of free movement of the ligament, and is perforated by numerous small vascular foramina.

Externally, the ridge ends at the outer border of the neck, and occasionally its termination is marked by a rounded tubercle, situated somewhat towards the anterior end of the external border. Occasionally we come across a specimen in which the outer portion of the superior surface is produced upwards into a well-marked crest.

This condition was first described by Hyrtl (5), who gave to it the name of the *processus trochlearis* (fig. 21). It is situated at the point where the upper surface of the neck passes into the external surface, just posterior to the articular surface of the caput. In shape it is an oblong low protuberance, in which we can distinguish an anterior and a posterior surface.

The posterior surface, in the specimen which Hyrtl described,

was saddle-shaped and covered with cartilage, and served as a groove in which the middle thick portion of the ligamentum talo-naviculare rested. In the specimens which I have examined, however, it was slightly convex in shape, and was more or less rough in character.

The anterior aspect is smooth and is slightly concave both from above downwards and from side to side; below, and to the inner side, this surface, in the great majority of cases, becomes continuous with the *facies articularis navicularis*.

The process is of infrequent occurrence: Hyrtl only obtained a single specimen. I have, however, found the condition occurring in 9 cases (Nos. 90, 185, 359, 529, 559, 585, 737, 774, 979).

I am inclined to regard this process as merely an abnormal development of the external portion of the ridge, which, as we have seen, runs across the upper aspect of the neck.

In a series of bones one can trace the gradual development of the small tubercle on the external border of the neck into, first, a low crest occupying the outer half of the superior surface, and continuous with the ridge internally, being separated from the articular surface of the caput by a smooth interval, and finally into a well-marked crest which completely obliterates the region of the neck in front of it.

The rest of the superior surface, that is, the part lying posterior to the ridge, between it and the *facies articularis superior*, is very vascular, and there are usually several large foramina situated along the anterior border of the articular surface.

Occasionally one comes across a specimen in which there is present a single very large vascular foramen, situated in the middle of the neck, which leads downwards into the substance of the bone; this condition seems to be of comparatively rare occurrence, and I have only found it in 13 specimens, which thus give us a percentage of 1.3. (The numbers of the specimens were as follows: 17, 29, 42, 50, 303, 353, 470, 583, 664, 709, 770, 869, 893.)

Facets on the Superior Surface.—As I have already pointed out (9), two articular surfaces are occasionally to be found on the upper surface of the collum tali, an internal and an

external; when present, they articulate with corresponding facets on the anterior border of the distal extremity of the tibia during extreme dorsi-flexion of the ankle-joint.

Facies articularis interna colli tali.—This facet was first mentioned by Parker and Shattock (7), who found it present in a case of talipes equinus; but it was not until some years later that a careful account was given by Professor Havelock Charles of the occurrence of the facet in the Punjabi astragalus (2). The articular surface is usually of a quadrilateral shape, and is produced by a forward prolongation of the facies articularis superior corporis tali along the inner margin of the neck (Pl. XX. fig. 22).

It is convex from side to side, and slightly concave antero-posteriorly. Internally it becomes continuous with the forward prolongation of the facies malleolaris medialis. In no case have I found this facet to be present unaccompanied by such a forward prolongation.

With regard to the frequency of occurrence of this articular surface, this varies very considerably in different races.

In the Egyptians I have found it to be present in 189 specimens, or a percentage of 19 per cent., whereas in the Punjabi, out of 53 cases, Professor Havelock Charles found 25 examples of the facet, thus giving a percentage of 47·2 (2).

TABLE II.—*Giving Frequency of Occurrence of Internal Facet on Collum Tali in two of the Human Races and in the Anthropoid Apes.*

	No. of Bones examined.	Facet present.	Percentage.
Egyptian	1006	189	19%
Punjabi (Prof. Havelock Charles.)	53	25	47·2%
Gorilla	6	1	16·5%
Chimpanzee	6	4	66·5%
Orang	15	13	86·5%

Professor A. Thomson also states that in the anthropoid apes, in some cases he found an extension forwards of the trochlear facet along the inner side of the neck, but in no instance did this articulate with a facet on the anterior margin of the inferior surface of the tibia (11).

I have also found this facet in the astragali of the anthropoid apes. It occurred most frequently in the orang.

Facies articularis externa colli tali.—On the external portion of the neck there is usually present a smooth tubercular ridge, which, in the position of extreme dorsi-flexion of the foot, fits into a hollow in the anterior margin of the distal or lower extremity of the tibia.

We may, however, find that its place is occupied by a definite articular surface, a corresponding facet being developed on the tibia, and between these two extremes we have all degrees of transition.

Professor Thomson, who was the first to describe this facet, distinguishes the following different conditions (10):—

1. Smoothing of the bone along the outer half of the upper margin of the neck.
2. The trochlear articular surface becomes insensibly blended with this smooth area.
3. The articular surface is well marked off: the facets may, however, differ in individual bones both in size and form.

In a well-developed specimen the articular surface presents a well-marked rounded anterior border, which separates it from the remaining non-articular portion of the neck; posteriorly we can recognise two conditions—in some cases the facet is separated off from the *facies articularis superior corporis tali* by a groove which runs horizontally across the articular surface (Pl. XXI. fig. 23), whereas in others there is no distinction between the two facets, the trochlear surface being continued forwards on to the neck.

The frequency of occurrence of this facet is found to vary very considerably in different races. In the Egyptian peoples I have found it to be present in 8·6 per cent. of the bones which I have examined—86 specimens in all. In the Punjabi,

however, Professor Havelock Charles found it to be present in 34 cases out of 53, thus giving for this race a percentage of 64.

The facet occurs in the European race in very rare instances only; Professor Pfitzner only found a single specimen during the careful examination of 840 bones (8).

TABLE III.—*Giving the Frequency of Occurrence of the External Facet in some of the Human Races.*

	No. of Bones examined.	Facet present.	Percentage.
European . . (Pfitzner.)	840	1	...
Egyptian . .	1006	86	8.6%
Andaman . . (Thomson.)	29	16	55%
Punjabi . . (Havelock Charles.)	53	34	64%
Australian . . (Thomson.)	18	14	78%

(For particulars with regard to the occurrence of the facet in other races, I must refer the reader to Professor Thomson's papers in the *Journal of Anat. and Phys.*, vols. xxiii. and xxiv.)

Professor Thomson also states that he has found this facet to be present in the astragali of the anthropoid apes (10).

In one specimen, No. 751, the trochlear facet was prolonged forwards on to the neck not as two separate facets, but as one single large facet situated approximately in the middle line.

With regard to the frequency of occurrence of these facets and the factors concerned in their production, there can be no doubt that they occur much more frequently in those races which 'squat' on the ground, and are absent or occur only very rarely in races that do not possess this habit, as in the European races of the present day.

As Professor Havelock Charles points out, prehistoric man (Neolithic and Cave-dwellers) probably squatted on the ground, and hence seems to possess these facets (3).

In the case of the anthropoid apes, we have seen that the internal facet is present to a varying degree in the astragali

of the different species. We must look for some reason, other than the above, to account for its presence in these animals.

According to Professor A. Thomson (10), it is probably due to the extreme dorsi-flexion of the ankle-joint during climbing, and hence is best developed in the Orang, which is acknowledged to be the most expert climber of all the anthropoids.

Another factor which we must consider is the size of the angle which the neck of the astragalus makes with the corpus in the vertical plane.

In the first part of this paper (9) we saw that in the European this angle possessed a much larger value than it did in the Egyptian. It is obvious that this must have a considerable importance, when we come to the question of the formation of facets on the neck of the astragalus; for there can be no doubt that facets would be much more likely to be formed in those bones which possessed a low value for this angle. That this is indeed the case is shown by a consideration of those bones which possess these facets: we have already seen that the average value for the angle between the collum and corpus, in the vertical plane, measures in the Egyptian astragalus 112° .

I have also measured this angle in those bones which have these facets, and I have found that in these cases the angle averages a value of only 110° .

This difference is certainly only slight, but the evidence becomes somewhat stronger when we come to consider the actual measurements. Thus, out of 72 bones examined, the angle was found to be less than 110° in 37 cases, thus:—

Value of Angle.	No. of Cases.	Value of Angle.	No. of Cases.
110°	2	103°	4
109°	4	102°	...
108°	5	101°	1
107°	2	100°	2
106°	7	98°	1
105°	3	94°	1
104°	5		

Professor Havelock Charles points out that these facets are found in the Punjabi foetus and infant, and he claims that we have here an example of the transmission of an acquired

character. To quote his own words: "The facets are seen on the bones of the Punjabi infant or fœtus, and have been transmitted by the accumulation of peculiarities gained by habit in the evolution of its racial type, in which an acquisition having become a permanent possession, profitable to the individual under its conditions of life, is transmitted as a useful inheritance" (3).

Unfortunately for this view, however, it has been shown that these facets occur in the fœtus of the European, and probably in all other races, whether the facets are found to be present in the adult or not; and this is after all what one would expect to be the case, when one considers that during intra-uterine life the lower extremities of the fœtus are in the position most favourable for the formation of such articular surfaces, viz., one of extreme dorsi-flexion and inversion.

The External Surface.—This surface of the collum tali is the large, usually more or less quadrilateral area of bone which forms, in the natural condition of parts, the roof of the sinus tarsi.

It is markedly concave, and faces downwards, outwards, and slightly forwards.

Posteriorly, it is continuous with the narrow area of rough bone situated on the lateral surface of the corpus in front of the facies malleolaris externa.

Anteriorly, it is sharply defined by the smooth articular surface of the caput, while below and to the inner side this area of bone narrows somewhat abruptly, and becomes continuous with the roughened area of bone on the inferior aspect of the collum, which forms the roof of the sulcus interarticularis.

In a well-developed specimen, this surface of the bone presents somewhat anteriorly a roughened area, which is usually of a circular or oval shape.

This area, in the fresh condition, gives attachment to the ligamentum talo-calcaneum laterale. As we have already noted, we occasionally get a tubercle present on the external border of the neck, and when this is present it probably serves as an extra attachment for this ligament, for in almost all bones in which it occurs the area for the attachment of the ligament is continued on to the under surface of the tubercle.

In the fresh state the sinus tarsi is to a large extent occupied by the internal limb of the ligamentum fundeiforme: this band, as Barclay-Smith has shown (1), passes into the sinus behind the ligamentum talo-calcaneum laterale, and divides into an inner and an outer portion, the fibres of which spread out in a fan-like arrangement. The outer head passes downwards to be inserted into the os calcis, while the inner passes into the sulcus tarsi to gain an attachment to both bones.

The outer surface of the collum is usually rather vascular; several large foramina are frequently to be found in the groove between the rough area for the lig. talo-calcaneum laterale and the articular surface of the caput; several other large foramina are generally situated close to the point where the sinus tarsi runs into the interarticular sulcus.

In connection with this surface, a small ossicle is occasionally found.

Ossiculum in sinu tarsi.—This little ossicle was first described by Gruber (4). In the case which he records, the ossicle was situated in the sinus tarsi between the ligamentum talo-calcaneum and the ligamentum fundeiforme, but united with the periosteum of the collum tali by a short fibrous band. The ossicle was shaped like a somewhat compressed pyramid.

In size it measured 1·3 cm. in height, 1·4 cm. in the transverse direction at the base, and 1 cm. thick. Pfitzner (8) regards it as either a pseudo-sesamoid or a calcareous concretion.

In one specimen which I have examined, No. 351, there is present on the posterior wall of the sinus tarsi a small bony excrescence, which measured 1·5 cm. in length and ·7 cm. in breadth, the long axis being situated transversely.

I am inclined to regard this as an example of the ossiculum in sinu tarsi, which has become fused on to the posterior wall.

The Inferior Surface.—This aspect of the neck is subdivided into anterior articular and posterior non-articular portions.

The posterior part is occupied by a deep groove, the sulcus interarticularis, which in the natural position of parts forms the upper segment of the canalis tarsi. The sulcus varies very considerably in breadth in different specimens, and as we saw when we studied the corpus (9), it may be almost completely

obliterated by the fusion of the *facies articulares calcaneæ media et posterior*.

Internally, the sulcus is shut off by the tubercular ridge which runs forwards from the anterior part of the *tuberculum mediale* to the *facies articularis calcanea media*, and serves as the dividing line between the inferior and mesial aspects of the neck (Pl. XXII. fig. 25).

In a well-developed bone, running forwards and outwards from this ridge, is another smaller ridge of bone, which divides the inner end of the *sulcus interarticularis* into two arms, an anterior and a posterior: this varies to a very great extent in its degree of development; in a large number of cases it is entirely absent, while in a few specimens (5 per cent.) it is, as we have already noted, largely developed, and bears a special facet for the calcaneum, the *facies articularis accessoria inferior* (9).

In the fresh state the sulcus is occupied almost entirely by ligaments: of these, two—the *ligamentum interosseum* and the *ligamentum fundeiforme*—are attached to this ridge; the latter ligament is, however, chiefly inserted into the *os calcis*.

Situated near the junction of the *sinus tarsi* and the *sulcus interarticularis*, and somewhat posteriorly, an elongated roughened area is usually to be recognised. This serves as an attachment for the *ligamentum talo-calcaneum anterius*, which is merely a thickened part of the capsule of the *articulatio talo-calcanea posterior*.

The roof of the *sulcus tarsi* is perforated by a number of vascular holes, which are usually arranged in two sets—an anterior, lying along the posterior border of the *facies articularis calcanea media*, and a posterior, along the anterior border of the *facies articularis calcanea posterior*.

The *anterior* part of the inferior surface of the *collum* is, as we have already mentioned, articular in nature, and is completely occupied by the *facies articularis calcanea media*.

Facies articularis calcanea media.—This facet is usually of an elliptical or rounded shape, being slightly concave in curvature antero-posteriorly, and flat or very slightly convex from side to side.

Posteriorly, it is usually marked off from the forward prolongation of the *tuberculum mediale* by a shallow groove,

which externally becomes continuous with the sulcus inter-articularis; in front, the articular surface passes continuously into the surface of the caput. The facet, however, is marked off from the facies articularis calcanea anterior and the articulation for the ligamentum calcaneo-navicularis by a low and usually not very distinct ridge; occasionally, however, this is of considerable prominence, the two articular surfaces on either side meeting at a considerable angle.

In several specimens the facet is separated from the articular surface of the caput by a notch which may be continuous with either the internal or external surface of the collum, and in a few cases there was a continuous groove bounding the facet in front and connecting the two lateral surfaces.

The facet presents numerous variations, which we may class as follows:—

1. Variations in size and shape.
2. Fusion with neighbouring facets.
3. Subdivision into two facets.

Variations in Size and Shape.—As we have already mentioned, the facet is usually of an elliptical shape, but it may occasionally be circular or even pyriform in outline, while in size it varies very considerably in different bones.

No. of Bone.	Total Length.	Greatest Length of Facet.	Greatest Breadth of Facet.
259	5·5	22 mm.	20 mm.
877	5·5	13 mm.	11 mm.

Fusion with Neighbouring Facets.—The most common form of fusion is with the facies articularis calcanea anterior. This condition is found to occur in about 9 per cent. of the bones, and when present it gives rise to a single long facet, which reaches from the caput to the sulcus interarticularis. We also frequently find that the facet is prolonged backwards along the ridge towards the tuberculum mediale (Pl. XXII. fig. 26); as we have already noted, when this ridge is well developed we may get a special facet formed on it, the facies articularis calcanea

accessoria. We must therefore regard this posterior prolongation of the *facies articularis calcanea media* as being produced by the fusion of these two facets; hence in such a condition we must recognise a *pars propria* in front and a *pars accessoria* behind. A similar condition is also found in the case of the *facies articularis calcanea posterior*, and in extreme cases we get a single long articular surface extending from the *caput* to the inferior aspect of the *corpus tali*.

We have also already pointed out that the *facies articulares calcaneæ media et posterior* may fuse directly and obliterate the *sulcus interarticularis*.

Subdivision in Two Facets.—This condition seems to be of rare occurrence, and I have only found it existing in a single specimen, No. 359.

In this bone the facet was replaced by two articular surfaces, separated from each other by a distinct ridge (Pl. XXIII. fig. 27). At first sight one is apt to mistake the most posterior of these facets for a *facies articularis accessoria inferior*, but on a careful examination the facet is seen to lie entirely in front of the anterior arm of the *sulcus interarticularis*, and one must therefore regard it as part of the *facies articularis calcanea media* which has become subdivided.

The Internal Surface.—This aspect of the neck comprises the rough non-articular area on the medial surface of the astragalus which is bounded anteriorly by the smooth articular surface of the *caput* and posteriorly by the *facies malleolaris medialis*; below this it becomes continuous with the non-articular portion of the internal aspect of the *corpus*. In the natural position of the bone the surface looks not only medialwards, but also to a slight extent upwards and backwards.

The breadth of this area is found to vary very considerably in different specimens; this is due chiefly to the variable length which the neck possesses, and to the variations in the extent to which the *facies malleolaris medialis* is prolonged forwards.

The articular surface of the *caput* is also in some specimens prolonged posteriorly, thus still further reducing the breadth, and in one case, No. 767, these two facets met, thus mainly obliterating the internal surface.

Inferiorly, the surface ends abruptly at the border of the

facies articularis calcanea media; superiorly, however, it passes almost indefinitely into the superior surface of the collum, and in rare cases, as we have already seen, all distinction into superior and medial surfaces is lost, and we get a continuous supero-internal surface.

In well-developed bones, we find that the ridge on the superior surface, which gives attachment to the ligamenta talo-navicularia, is continued on to the medial aspect for a variable distance: in the majority of cases it runs downwards and backwards to the border of the facies malleolaris, where it is lost, but in a few cases it becomes continuous with the ridge which runs forwards from the tuberculum mediale on the medial aspect of the corpus.

One occasionally finds that on this aspect of the neck there is developed a special facet: when present, it is caused by the articulation with the astragalus of a small ossicle, the *tibiale externum*.

The facet varies very considerably; it is usually situated near the lower border of the surface, and according to Pfitzner (8) is generally completely separate. In the specimens which I have examined, however, the articular surface was continuous with the smooth caput, being merely marked off from the articular surface by the tendon of the tibialis posticus muscle by a low ridge (Pl. XXIII. fig. 28).

It is of infrequent occurrence, and I have only succeeded in finding it in two specimens, Nos. 20 and 264.

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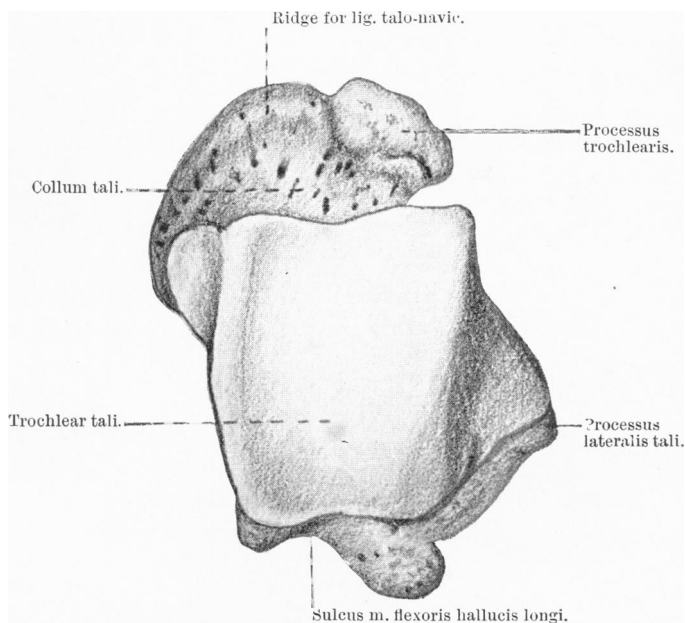


FIG. 21.—Norma verticalis—showing a processus trochlearis on the collum. No. 979.

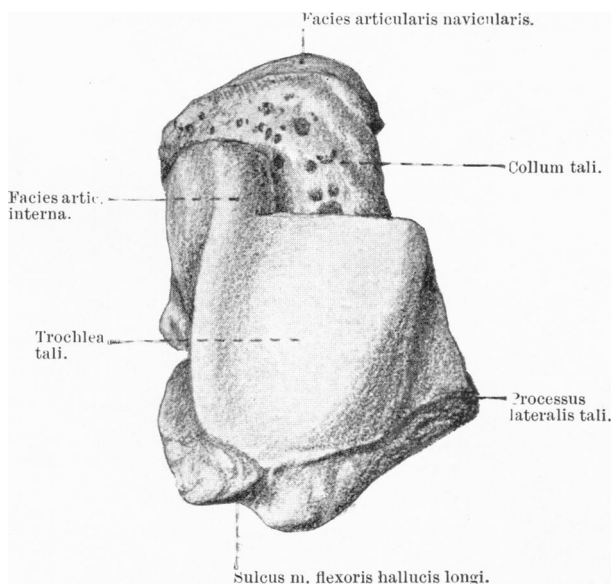


FIG. 22.—Norma verticalis—showing facies articularis interna on the superior surface of the collum. No. 619.

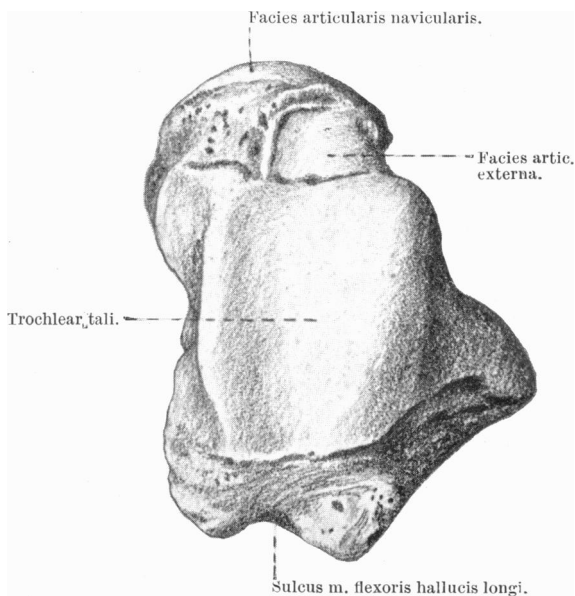


FIG. 23.—Norma verticalis—showing facies articularis externa on the superior surface of the collum. No. 362.

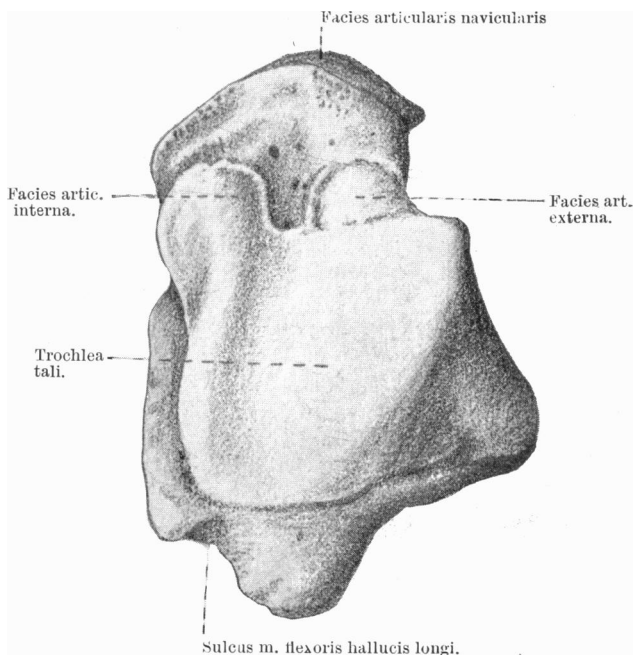


FIG. 24.—Norma verticalis—showing both facies articularis, interna and externa, on the superior surface of the collum. No. 732.

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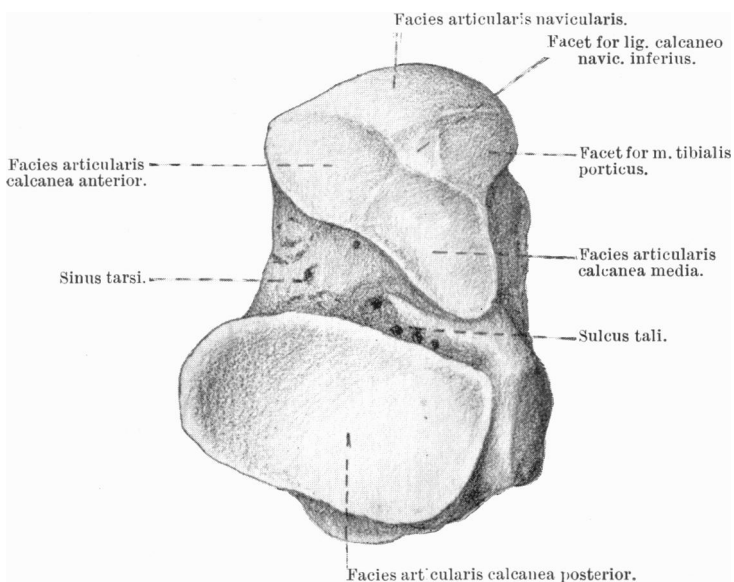


FIG. 25.—Norma basilaris—normal bone. No. 751.

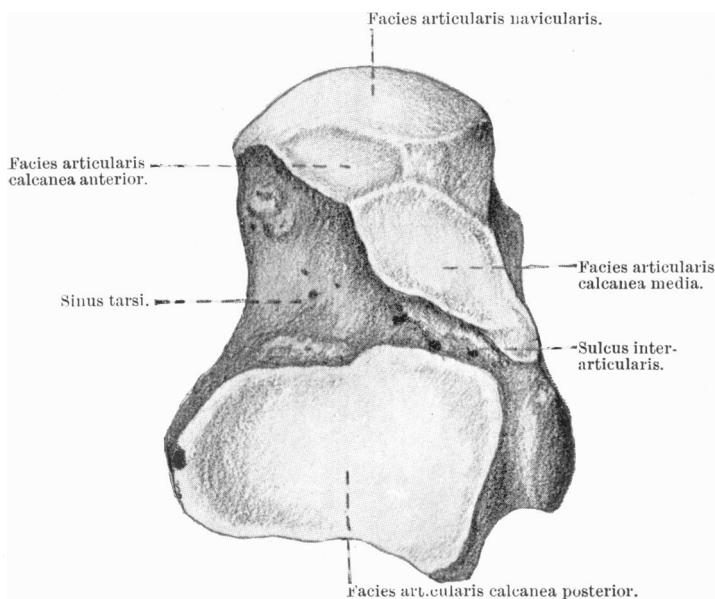


FIG. 26.—Norma basilaris—showing backward prolongation of facies articularis calcanea media. No. 794.

MR R. B. SEYMOUR SEWELL.

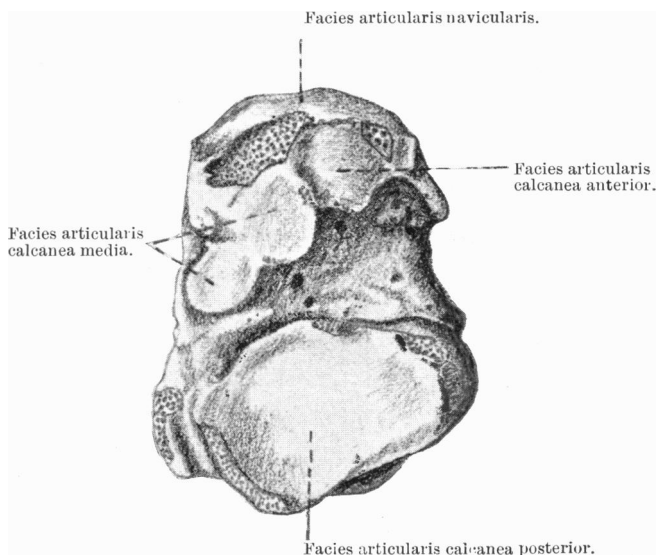


FIG. 27.—Norma basilaris—showing subdivision of the facies articularis calcanea media. No. 359.

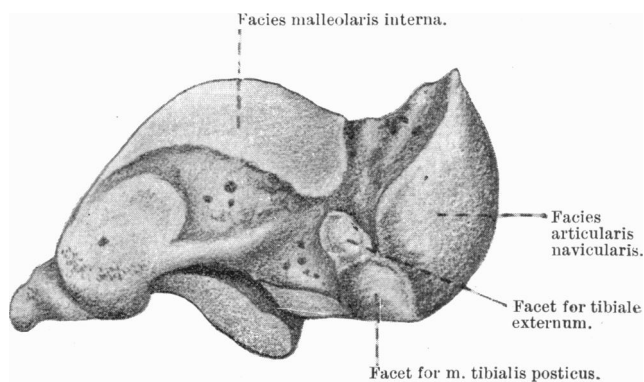


FIG. 28.—Norma medialis—showing facet for the ossicle, tibiale externum. No. 264.